not highly correlated to material discount levels or any efficiencies achieved through the deployment of different technologies.

Q. How was the FLC factor used by Verizon MA developed?

A. A proper calculation of the FLC ratio would require the Company to examine the total plant investments in the TELRIC filing to the total plant investments contained in the Massachusetts accounting records. Since this calculation cannot be developed until the TELRIC investment studies are completed, the Company relied on an evaluation of data supplied in the recently litigated New York UNE proceeding. This data suggests that a ratio between 75 percent and 80 percent is a reasonable approximation going forward. Verizon MA conservatively used an 80 percent ratio in this filing.

Q. Please explain the effects of employing the ACF FLC Factor.

A. The FLC Factor adjusts each component part of the ACFs to properly match the investments or expenses used to create the ACFs with those used to identify the forward-looking expenses in the recurring studies. The table below shows the consequences of a FLC Factor that adjusts for a situation where the level of forward-looking investment in the studies is less than the level of investment used to develop the ACFs.

Application of a Forward-Looking Conversion ("FLC") Factor				
(Example Correcting for a Shortfall)				
Line	Item	Source	Amount	Comments
1	Forward-Looking Expense		$300	Estimate of True Forward-Looking Expense
2	Current Investment		$1,000	Investment denominator of ACF ratio
3	Annual Cost Factor (ACF)	L1 / L2	.3000	Calculated ACF
4	TELRIC Investment		$800	Forward-Looking Investment
5	Purported TELRIC Expense	L4 x L3	$240	Pseudo – "Forward-Looking" Expense
6	Shortfall	L1 – L5	$60	Unidentified True Forward-Looking expense
7	FL/C Adjustment Factor	L4 / L2	.8000	Forward-Looking Conversion Factor
8	Adjusted ACF	L3 / L7	.375	Identifies appropriate amount of expense
9	TELRIC Expense	L4 x L8	$300	Appropriate level of Forward-Looking expense
10	Shortfall	L1 – L9	$0	Shortfall eliminated

Q. The above example shows an adjustment made where the forward-looking investment is less than the investment used in the development of the ACFs. Would an adjustment be appropriate if the forward-looking investment were greater?

A. Yes. In that instance, the adjustment factor would be greater than one and consequently the adjusted ACF would be less to avoid the over-identification of expense. Likewise, if the investments used to build the ACFs and the forward-looking investments were comparable, no adjustment would be called for.

Q. What kind of an adjustment is made to ensure that as ACFs are applied to lower TELRIC investments and expenses (in the case of overhead and gross revenue loadings), the correct amount of forward-looking expenses is identified?

A. The Network, Wholesale Marketing, and Other Support factors are divided by this ratio in order to yield equivalent TELRIC ACFs that are to be appropriately applied to TELRIC investments. The ACF_{COH} is also adjusted but in a different manner as described below.

Q. Please describe the adjustment to the $ACF_{COH.}$

A. The same concepts that relate to the other ACFs are applicable to the Common Overhead ACF. However, since in some studies this factor is applied to the identified costs (expenses as well as capital costs), it would be inappropriate to apply a forward-looking adjustment to the ACF_{COH} for the portion of the identified costs that already reflect a apply a forward-looking adjustment. That is, it would be inappropriate to adjust the ACF_{COH} when it is applied to the network, wholesale marketing or wholesale other support components of the identified costs. Therefore, a weighted average adjustment is created for the ACF_{COH}. In developing the ACF_{COH}, the Company identified expenses (which would be adjusted with a FLC Factor) and capital costs or other expenses (which would not be adjusted by FLC Factor) to be used in the denominator. The relative percentage of adjusted expenses to non-adjusted expenses/capital costs is used to come up with a weighted average for the forward-looking adjustment for the ACF_{COH}.

Q. For any given study, when is it appropriate to use the ACF_{COH} that reflects the full forward-looking adjustment versus the ACF_{COH} that reflects, instead, the weighted average application of that adjustment?

A. If the study contains expenses that have already been adjusted with a FLC Factor, then the ACF_{COH} with the weighted average adjustment is appropriate. If the study does not contain expenses that have already been adjusted with a FLC Factor (*e.g.*, non-recurring studies), then the unadjusted ACF_{COH} (*i.e.*, the one with the same adjustment factor used for the Network, Wholesale Marketing and Other Support ACFs) is most appropriate.

VI. OVERVIEW OF THE NETWORK TECHNOLOGY MODEL ON WHICH THE COST STUDIES ARE BASED

Q. Please provide a general description of the forward-looking network technology architecture that forms the basis for the cost studies submitted in this proceeding.

A. The Massachusetts' network is composed of a complex array of technologies and systems that inter-operate to provide telecommunications services. It is best understood when subdivided into its major functional components:

(a) local loop transport facilities,

(b) local switching facilities, and

(c) the facilities that interconnect Massachusetts' wire centers with each other and with the networks of other carriers.

Q. How do the three major functional components relate to the unbundled network elements identified in the Company's cost studies?

A. "Local loop transport" is the loop element; "Local switching" is the local switching element; and the "interconnection" category includes tandem switching, interoffice transport (dedicated and common, and signaling systems (signaling links, STPs, and SCPs) each of which is separately considered.

VII. LOCAL LOOPS

A. In General

Q. What is the “local loop” network element?

A. FCC Rule 319(a) defines the unbundling requirement for the “local loop” network element as follows:

> (a) Local Loop and Subloop. An incumbent LEC shall provide nondiscriminatory access, in accordance with § 51.311 and

section 251(c)(3) of the Act, to the local loop and subloop, including inside wiring owned by the incumbent LEC, on an unbundled basis to any requesting telecommunications carrier for the provision of a telecommunications service.

(1) Local Loop. The local loop network element is defined as a transmission facility between a distribution frame (or its equivalent) in an incumbent LEC central office and the loop demarcation point at an end-user customer premises, including inside wire owned by the incumbent LEC. The local loop network element includes all features, functions, and capabilities of such transmission facility. Those features, functions, and capabilities include, but are not limited to, dark fiber, attached electronics (except those electronics used for the provision of advanced services, such as Digital Subscriber Line Access Multiplexers), and line conditioning. The local loop includes, but is not limited to, DS1, DS3, fiber, and other high capacity loops.

(2) Subloop. The subloop network element is defined as any portion of the loop that is technically feasible to access at terminals in the incumbent LEC's outside plant, including inside wire. An accessible terminal is any point on the loop where technicians can access the wire or fiber within the cable without removing a splice case to reach the wire or fiber within. Such points may include, but are not limited to, the pole or pedestal, the network interface device, the minimum point of entry, the single point of interconnection, the main distribution frame, the remote terminal, and the feeder/distribution interface.

B. TYPES OF LOOPS CONSIDERED IN THIS TESTIMONY

Q. What types of loops are considered in this testimony?

A. This testimony addresses all of the loop types described in Rule 319(a). Specifically, costs are determined for:

- Two- and four-wire analog loops and two-wire digital loops;
- Four-wire digital (DDS) loops;
- Four-wire digital (DS1) loops;
- ADSL-compatible loops, two-wire HDSL-compatible loops, and four-wire HDSL compatible loops;
- Conditioning charges for DSL-compatible loops;
- Line sharing;
- High-capacity (DS3 and above loops);
- House and riser and other "subloops"; and
- Dark fiber loops.

C. Technical Assumptions, Utilization Factors, and Costs for Specific Loop Types

1. Two- and Four-Wire Analog Loops; Two- and Four-Wire Digital Loops

Q. What is a two-wire analog loop?

A. A two-wire analog loop is a transmission circuit consisting of two wires that is used to both send and receive voice conversation in the 300-3000 Hz frequency range. This is the basic loop type used for providing voice-grade "POTS" service.

Q. What is a four-wire analog loop?

A. A four-wire analog loop consists of two pairs, one to transmit and one to receive. It is used in certain private line and data service applications.

Q. What is a four-wire digital (DDS) loop?

A. A four-wire digital (DDS) loop is a four-wire loop "conditioned" for the transmission of digital data service applications.

Q. What is a two-wire digital loop?

A. A two-wire digital loop is a two-wire loop "conditioned" for the transmission of certain high-speed data services. In particular, Verizon MA's two-wire digital ("premium") loop can be used to provide ISDN – Basic Rate Interface ("BRI") service to an end user customer.

Q. What is a four-wire digital loop?

A. This is a conditioned, four-wire loop that will support DS1 transmission. It can be used, among other things, to provide ISDN – Primary Rate Interface ("PRI") service to an end-user customer.

a) Technical construct

Q. Describe the forward-looking loop infrastructure that will be used to provision loops.

A. The first major functional component of a local exchange network, local loop transport, comprises all the physical transport facilities that connect an end-user customer location to a wire center. These facilities are commonly referred to as "loops" in the telephone industry.

Q. What is a wire center?

A. A wire center is typically a building where loop facilities serving a particular geographic area, and interoffice cable facilities, terminate on physical arrays called "distribution frames." The building also contains switching equipment and other electronic equipment that provide telecommunications functions.

Q. How has the geographic area served by each wire center been determined?

A. Determinations as to the areas to be served by particular wire centers have been based on a trade-off between the number of customers in the area and the length (and transmission characteristics) of the loop facility needed to reach the most distant customer. In other words, while expanding the service area covered by a wire center to encompass more distant customers might reduce the number of wire centers required, it would also necessitate longer, more expensive loops. In large cities, the density of customers has been the overriding factor, and wire center service areas are no more than a few miles in radius, typically serving 100,000 lines and more. Outside the large cities, one wire center has usually been created in each significant town. The size of the areas served by wire centers varies widely today. Heavily populated suburban wire centers typically have shorter loops, whereas rural loops are often much longer and a wire center may have only a few hundred to a few thousand lines.

Q. What function is performed by a loop?

A. The purpose of a loop is to carry a signal (for example, representing a voice communication) between a customer's premises and a central office, with distortion and diminution of the signal maintained at an acceptable level.

Q. What facilities are required to provide this functionality?

A. The primary components of a loop are:

(a) cable (*i.e.*, the physical medium that actually carries the signal);

(b) structure facilities that physically support the cable (*e.g.*, poles, conduit, etc.);

(c) additional support facilities that may be necessary to provide protection against water and other factors that could impair signal transmission (*e.g.*, air pipe, load coils, repeaters, surveillance alarms); and

(d) electronic elements needed to convert and combine signals (*e.g.*,multiplexers).

Q. What types of cable are utilized in loops?

A. In general, loop cable can be either copper (which conducts signals as electrical impulses) or optical fiber (which conducts signals as light pulses).

Q. What is the design that the Company has utilized for its existing copper loop plant?

A. The wire center is usually located in the approximate center of the area served to minimize the average length of the loop facility needed to reach each customer location. Most of the existing loop facilities were constructed with copper cables, which consist of an outer plastic tube or sheath containing hundreds or even thousands of individual copper wires. Working telephone circuits are served with a dedicated pair of these copper wires, extending from the customer's premises to the main distribution frame in the local wire center. To make construction and administration manageable, the cable emerges from the wire center in large size sheaths and is tapered to smaller and smaller cables as it branches out to the customers. A typical loop facility route may be thought of as a tree with the trunk rooted in the wire center and the branches spreading out to the customers. Cables are divided and spliced to smaller units at each of the branches. In residential or small commercial zones, a "serving area interface" or SAI is usually established at a point where the main cable from the wire center, called the "feeder", branches to a smaller area, called a distribution area, typically containing a few hundred customers. The SAI has the functionality of a flexible splice and is used to manage growth in a distribution area. More pairs are provided in the distribution area cable than the number of feeder pairs branched to that particular distribution area. The location of the SAI is designed to minimize the length of feeder cable and the length and size of the distribution cables required to meet demands for growth and churn. At a pole or building near a group of customers, a properly sized number of distribution pairs is terminated in an apparatus called the "drop terminal" (typically a small box) where individual pairs can be connected to a customer via a "drop wire." The drop wire is a small cable, usually two or four wires, that connects the drop terminal to the customer's premises. In a multi-unit dwelling the drops may be enclosed in a common "riser" cable that delivers a few pairs from the basement to each living unit.

Q. Please describe the evolvement of the technology of the loop.

A. In recent years, the development of digital electronic systems and optical transmission has increasingly provided a new and more economic way to build loop facilities, utilizing what is known as "digital loop carrier" ("DLC") technology. DLC technology converts voice and other analog signals into a digital signal that can be combined or "multiplexed" with other such signals and sent over a shared "carrier" facility. The first DLC systems used copper pairs for transmission of the digital signal back to the wire center, but today DLC systems using optical fiber systems are the most efficient DLC technology. The cost of DLC technology initially made it economically efficient only for use on the longer subscriber loops. As the cost to deploy fiber fed electronic systems decreases, its use is more economical for applications with less access lines or fewer high speed digital service requirements and within shorter distances from the CO.

Q. Is this consistent with the technology that the Company has in its network today, and also used in its network model?

A. Yes. In a forward-looking network, the long-term objective is to work towards an all fiber-fed DLC network, reducing the copper cable length to the customer. However, copper cables continue to be the economically efficient design choice for many feeder loops nearer to the serving wire center.

Q. Describe the loop architecture utilized in your forward-looking network model.

A. In the forward looking network model, a combination of fiber-fed DLC and copper cables are utilized to provide feeder facilities. The use of copper feeder is limited to those loops typically closer to the central office, while fiber fed DLC is used beyond that point. This combined design strategy (copper and fiber) eliminates costly network elements required for longer loop copper designs (heavier gauge cables, load coils, repeaters). On longer loops, at the branch to a distribution area, fiber is placed to an electronic device called a remote terminal ("RT"). The RT terminates the optical system and provides the digital decoding/encoding and multiplexing functions that allow the many individual lines to be transmitted on the optical system. Each individual line or "channel" on the system has a port on the RT with a device (channel unit) that converts the information on a standard 3 kHz bandwidth, analog voice frequency line into a standard, 64 Kbs, digital DSO format. Each channel unit is connected by copper cable to a nearby distribution area cross-box, where the RT channels can be connected to the copper distribution cable pairs that run to customer locations.

Q. What do you mean by "DSO format"?

A. DSO (Digital Signal 0 Level) is a unit of digital signal that provides an information-carrying channel within a digital facility. In general, a DS0 channel provides sufficient digital signal to carry one standard voice grade signal with a 3kHz bandwidth. Higher capacity digital signals are referred to, for example, as "DS1s" and "DS3s" and are constructed by adding together (multiplexing) lower signals (a DS1 can contain 24 DSOs, a DS3 can contain 28 DS1s).

Q. Please continue your discussion of a modern, forward-looking loop plant architecture.

A. Thus, the typical modern loop facility is a hybrid. On longer loops the facility consists of the copper drop, feeder, and distribution cable from the customer location to the optical RT and the digital channel on the fiber optic system back to the wire center. Depending on density, the RT is located as close to the customer as possible, thus minimizing the length of the distribution cable and maximizing the substitution of fiber for copper. In very concentrated applications like high rise, multi-unit dwellings, it is economically efficient to install the optical RT in the basement or other common space in the building and completely eliminate the copper feeder cable. In other areas, some feeder and distribution cable is required to bring together enough customer lines to efficiently use the expensive RT facility. Nearer to the central office, an all-copper solution may still be economically more efficient than fiber-fed DLC.

Q. How do optical DLCs terminate at the wire center?

A. In the wire center, the optical DLC cable terminates on the wire center's fiber distribution frame ("FDF") and is connected from there, by fiber cabling, to a piece of equipment called the central office terminal ("COT"). The COT can provide an interface to local switching equipment or other transmission systems (for example, those systems providing interconnection to another carrier's network) either (a) in a standard, 24 DSO-line digital format (known as an "Integrated Digital Loop Carrier" [IDLC], or DS1 connection) or (b) as an individual analog channel (after decoding and demultiplexing) connected to copper wire interfaces (known as "Universal Digital Loop Carrier" [UDLC]). A "universal" interface can be connected to any type of voice frequency switch port or telecommunications equipment on the main distribution frame.

Q. Which of the two COT interfaces -- integrated or universal -- would be used in designing an efficient, forward-looking network?

A. Both would be used depending on the service that is ordered by the

CLEC. For example when a CLEC orders an individual 2-wire analog loop, physically and technically this can only be handed-off (connected) to the CLEC using the universal interface.

Q. What types of services are provided over integrated DLC in a forward looking model?

A. Fiber-fed DLC switched services are provisioned using an integrated DLC in the forward looking model. Other services require a universal interface, such as individual 2-wire analog loops or data services like ISDN and DDS.

Q. Which of the two COT interfaces – integrated or universal – would be used in providing access to a (UNE) loop?

A: In order to access a 2-wire analog UNE loop, a physical point of interconnection is needed. For this reason, a universal DLC or UDLC interface is needed. Integrated DLC, IDLC, does not have a physical 2-wire connection in a central office. Therefore, a CLEC cannot connect to the 2-wire analog loop unless UDLC or copper cable is used.

Q. How does the loop transport facility of a modern forward-looking network compare with the loop facility analyzed in the Company's cost studies?

A. The two are fully consistent. First, with respect to feeder plant, as described above, the economic efficiency of optical DLC has reached a point where much of the feeder capacity can be efficiently created using these systems. Optical DLC is usually installed first in feeders serving distribution areas that are more distant from the wire center, since it is in such areas that optical DLC provides the greatest efficiencies. The copper feeder cable that is made spare (*i.e.*, freed up) by the DLC installation is then cut and used to provide capacity to distribution areas closer to the wire center. Over time a greater and greater portion of the feeder will be moved to optical facilities.

Our forward-looking model assumes that feeder capacity is placed on the most efficient optical DLC currently available from suppliers. Copper feeder deployment is limited to areas where the economic advantages of fiber do not exist. This is the design that Verizon MA plans to employ for the foreseeable future.

Q. Is this the same network design presented in the Company's 1996 TELRIC study in the Consolidated Arbitrations?

A. No. The Company's 1996 TELRIC study was based on a loop construct consisting of 100 percent fiber in the feeder plant. In addition, the 1996 construct assumed that all unbundled two-wire loops could be served on an integrated digital loop carrier ("IDLC") interface.

Q. Why did Verizon MA change its cost study assumption for this filing?

A. The assumption of 100 percent IDLC adopted in the 1996 study reflected a network construct that, as described above, was not appropriate for provisioning unbundled loops. The Company now realizes that it was not necessary to base its 1996 cost estimates on an assumption of 100 percent IDLC.

In order to be consistent with the FCC's principles, a forward-looking TELRIC estimate should account for costs based on the forward-looking technology currently deployed using the most efficient methods and practices developed by engineers for current, actual use in planned plant investment decisions and construction.[15] As described above, this TELRIC study is consistent with those principles and reflects the design that Verizon MA plans to deploy for the foreseeable future. The 1996 study based on 100 percent fiber was consistent with the Company's long term planning objectives, but did not reflect the forward-looking costs that Verizon MA would actually expect to incur over any reasonable planning period.

Q. Is the Company's choice of technology for the distribution plant

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[15] This principle is discussed in the Direct Testimony of William E. Taylor and also in *Local Competition Order* ¶¶ 683-685.

consistent with your network model?

A. Yes. As previously discussed, the efficiency of optical loop systems is determined chiefly by the density of the lines in the area served. This is because the electronics in the RT represent the majority of the cost. The smallest RT unit economically efficient with existing technology provides capacity for about 100 customer lines. In areas were the RT can be placed within 500 feet of about 100 customers, it is economically efficient to totally eliminate the copper feeder cable. This occurs, for the most part, only in dense urban areas and large multi-unit housing complexes. In all other areas, a limited length of copper feeder and distribution cable is required even in the forward-looking model to aggregate enough lines at the RT to make it efficient. The loop models described in the Company's testimony properly reflect the mixture of optical DLC, copper feeder and copper distribution cable required to efficiently address the density of the particular type of area covered by each model.

b) Utilization Factors for Local Loop Components

i) DISTRIBUTION CABLE

Q. What utilization factor was used for distribution cable in Verizon MA's studies?

A. A factor of 40 percent was used.

Q. How was this factor derived?

A. Distribution utilization is determined by two major factors: designing for long-term demand and construction breakage. Residential demand is the primary driver of utilization in the distribution plant. This study conservatively follows the long standing industry practice of allocating at least two distribution cable pairs per-zoned residential unit. Allocating pairs consistent with zoning provides for the long-term demand that could occur in an area if all the zoned land is developed and all potential customers use Verizon MA distribution facilities. The two-pairs per unit assumption accommodates the statistical peaks in per customer demand. If the ultimate demand level were attained, then the average distribution fill would be approximately 60 percent given the average residential demand of 1.2 lines per living unit. In any real network, the actual demand level is significantly less than the ultimate. Undeveloped land, vacancies, and the fact that all customers do not use the Verizon MA infrastructure contribute to reduce the actual demand. "Forward looking" estimates for these factors can be derived from experience and public information.

Even in the most mature demographic areas, a significant fraction of the land zoned for use is not currently in use. For the forward-looking model, the Company has made the very conservative estimate that on average 90 percent of the zoned units have been built, and hence the current maximum potential demand is 90 percent of the ultimate demand.

While new housing units are added at a steady rate, an important fraction of existing units are vacant at any point in time. Because distribution plant is by its nature dedicated on average to a small physical area, the distribution plant allocated within ultimate design to serve these vacant units must be spare. Business vacancies also occur and contribute to the spare. We have assumed that 5 percent of the ultimate demand is not realized at any point in time because of vacancies.

For a variety of reasons, some business and residential units, while occupied, do not obtain telephone service using the Verizon MA distribution network. Competition and service substitution have and will increasingly attract potential business and residence customers away from wireline local telephone service. Wireless alternatives and facilities-based competition have already begun to attract demand away from the local telephone network. The distribution plant allocated to these customer locations is left spare. For this analysis, we assume that 10 percent of the potential customers do not use Verizon MA distribution facilities. This is a highly conservative estimate since major competitors such as AT&T have publicly touted their objective of attracting 25 percent of the local access business onto their alternative networks within the next five years.

Combining these three factors, yields an estimate that only 75 percent of the zoned living units in an average Distribution Area will actually be generating Verizon MA demand in a forward-looking scenario. This means that the anticipated utilization of the available distribution pairs, which are sized to serve 100 percent of the units, is 1.2 times 75 percent divided by 2 or 45 percent. The actual utilization of distribution investment must be lower than this number because of construction breakage.

Construction breakage has a major impact on the utilization of distribution investment. Copper cable comes in fixed sizes: 25, 50, 100, 200, 300, 600 pairs, etc. As cables are branched down streets, the pairs required rarely fit the cable size perfectly and the next largest size cable that meets the demand must always be chosen. For example, if a street requires 60 pairs, a 100 pair cable must be run since the next smallest size, 50, does not satisfy the demand.

This is an exaggerated but not unusual example. As the branch cables are combined back toward the SAI, some but not all of this unused capacity is eliminated. Cables are manufactured and spliced in units of 25 pairs called binder groups. In the example given above, only three binder groups, 75 pairs, would be spliced into the larger cable at the block branch point. This would eliminate 25 of the pairs unused in the 100 pair block cable but 15 pairs would remain unused in the larger cable. These pairs must remain spare all the way to the SAI but they are not included in the available inventory at the SAI. Thus, the distribution cable inventory recorded in the SAI is always less than the actual installed distribution cable capacity. There is also local breakage along the distribution cable.

Returning to the example above, the 100 pair cable is run down the whole street and passes many local drop terminals. At each one, two pairs are terminated for each living unit and are left spare in the remainder of the cable that runs down the street. When the last terminal is reached, most of the cable is left spare. In fact, at most, about 50 percent of the actual cable capacity will be used on branch cables down streets. Any size breakage reduces this number. Although at first blush it might seem that tapering could mitigate this reduced utilization, the reality of placing and splicing many short little segments of cable makes this an impractical alternative. There is also similar breakage along the larger cables that pass the local streets. For example, if the large cable is 300 pairs and 50 pairs must be dropped down a street, those 50 pairs must be left unused in the large cable as it continues, since a 250 pair cable is not available. How far the unused capacity continues in the cable depends on the requirements at the next branch point. The precise amount of unused capacity in a distribution area can only be determined by an exhaustive manual study of the cable layouts. A very conservative estimate is that on average 10 percent of the installed distribution cable investment is left unused because of construction breakage. This is equivalent to saying that for every nine pairs of available distribution capacity created, the equivalent investment of one pair is left unused.

Using the 10 percent breakage factor, the forward-looking utilization of distribution investment is estimated to be the 45 percent utilization of pairs available for assignment calculated above, multiplied by 90 percent or 40.5 percent. This analytically derived figure is consistent with the 40 percent used in this study.